

SWITCHING CONVERTER

The present invention pertains to a switching converter, in which an input voltage can be switched by means of at least one controlled switch to at least one primary winding of a transformer, with a control circuit for controlling the switch, to which a regulating signal is sent in the sense of regulating at least one output voltage, wherein the control circuit is supplied with power via the forward voltage of an auxiliary winding of the transformer, a rectifier, a capacitor and a series regulator, on the one hand, and, on the other hand, starting from the input voltage, via a current path and a storage capacitor.

In such switching converters, the control circuit receives a rectified output voltage via a series regulator via the auxiliary winding, which operates in the conduction phase of the converter. To also guarantee the start-up of the control circuit when it is connected to the output voltage, the supply voltage input of the control circuit additionally lies on the input voltage via a current path of a relatively high ohmic resistance.

The basic problem of the present invention arises when a broad range of variation of the input voltage is present, at which the converter is to operate. The input voltage is usually obtained by rectifying a power supply and is also called intermediate circuit voltage. If the alternating voltage is in a range between 85 V and 264 V, a direct input voltage of approx. 115 V to 373 V is obtained. A certain minimum voltage of the auxiliary power supply, for example, 15 V, is required for the control circuit. This voltage must be guaranteed at the lowest power supply. However, it follows from this that a high direct-axis voltage component of about 34 V is present on the series regulator at the highest input voltage occurring, so that a power loss of 0.84 W is generated in case of a control circuit power supply of, for example, 25 mA. Such a power loss is undesirable especially in case of small devices.

An embodiment according to the state of the art is explained in greater detail in Figure 1. An alternating input voltage U_E lies via a controlled switch S on a primary winding W_p of a transformer UET . The switch S is controlled by a control circuit AST ,

this control circuit receiving information on the current through the switch S and the primary winding W_p by means of a sensor resistor R_{sh} .

On the secondary side, the voltage of a secondary winding WS is rectified by means of a rectifier diode D1 and smoothed by a capacitor Ca and is available as an output voltage U_A . A voltage sensor SPS sends a regulating signal s_R to the control circuit via an optocoupler in order to bring about voltage regulation in the known manner. However, regulation may also take place from the primary side, and input/output currents can also be included in the regulation. The control circuit receives its operating voltage in two different ways: On the one hand, the direct input voltage U_E is sent via a protective resistor R_s to the control circuit AST, using a storage capacitor Cs is this case. On the other hand, the forward voltage of an auxiliary winding W1 is rectified by means of a diode D2 and a capacitor C and is sent as a voltage U_{hz} to a series regulator LAE, from where the regulated voltage likewise reaches the power supply input of the control circuit AST via an uncoupling diode D3. The primary mass is designated by M_p and the secondary mass by M_s .

If the switching converter according to Figure 1 is connected to the power supply, it first receives the voltage present on the storage capacitor Cs for start-up and after the run-up of the combinational switching circuit, this will supply itself with the auxiliary supply voltage via the auxiliary winding W1, the diode D2 and the series regulator LAE. As was mentioned above, a high direct-axis voltage component also lies on the series regulator LAE in case of a high input voltage, which leads to undesired losses.

The following documents shall also be cited below in connection with the general state of the art:

WO 93/23974 shows a switching converter, which has an auxiliary supply winding. An auxiliary supply voltage can be obtained via this winding in the flyback converter mode. Moreover, an image of the output voltage can also be obtained from this winding for regulating purposes by the use of two diodes. Moreover, the generally common power supply from the input voltage via a voltage divider is likewise present.

DE 3 419 972 A1 shows a combinational switching circuit, which can optionally be operated at a power supply voltage or a battery voltage. Just as in WO 93/23974 mentioned above, an auxiliary winding is provided here as well, which supplies an off-

state voltage for supplying the control unit (after rectification). Furthermore, this combinational switching circuit has two separate primary windings, wherein one primary winding is provided for operation with the rectified alternating power supply and the other primary winding for the operation with a 14-V battery. Finally, yet
5 another auxiliary winding may also be present, whose voltage is used for regulating purposes and is supplied to a control circuit for this purpose.

The document JP 09-285 121 discloses two mutually independent converter systems, which do, however, form a functional unit and are to be synchronized with one another such that a defined sequential sequence is obtained during the voltage
10 run-up. Only one of the two converter systems has an auxiliary winding, whose voltage is used for the power supply of the control circuit after rectification. The other converter system cannot start by itself at all but requires the second, run-up converter system.

The switching converter according to US 4 156 273 has two auxiliary windings.
15 One of these auxiliary windings supplies, after rectification, a supply voltage for the control circuit, and this supply voltage can be switched on or off via a controlled switch. The other auxiliary winding has nothing to do with power supply, but the voltage derived from it shall affect the switching behavior in terms of a desired curve shape.

20 In US 4 630 186, a bipolar transistor, which exhibits a relatively sluggish behavior, is used as the switching transistor. To make possible the fast switching off of this switching transistor, an auxiliary winding is provided, which generates a countervoltage, which is applied to the control electrode of the switching transistor via another switching transistor at a suitable point in time. Yet another auxiliary winding
25 supplies a voltage, which is to affect the switching behavior. Together with a rectifier diode and a capacitor, this auxiliary is called a voltage correction circuit.

One object of the present invention is to create a combinational switching circuit which is suitable for a broad range of input voltages and yet has low losses during the generation of the auxiliary supply voltage for the control circuit.

30 This object is accomplished with a switching converter of the type mentioned in the introduction, in which the off-state voltage of an auxiliary winding, which is rectified by means of a rectifier, is sent according to the present invention additionally

to the control circuit for power supply, wherein the rectified off-state voltage is used during the operation to supply the control circuit as long as it has a sufficient voltage level.

In a switching converter according to the present invention, the control circuit
5 AST is supplied in normal operation utilizing the rectified off-state voltage, so that no current flows through the series regulator. This becomes active only when the voltage drops greatly at the output, e.g., in case of short-circuit or during the run-up phase. It shall be summed up here that a total of three voltage supplies are present according to the present invention for the control circuit, namely, first, a supply voltage that is
10 derived from the high input voltage via a resistor with high ohmic resistance and is used to start the control circuit; second, a supply voltage that is derived from the forward voltage of an auxiliary winding and supplies the control circuit during normal operation, and, third, a supply voltage that is derived from an off-state voltage of an auxiliary winding and is then used when the output is short-circuited or is overloaded.

15 Provisions are made in an advantageous embodiment of the present invention for another auxiliary winding of the transformer to be provided for generating the off-state voltage, wherein this off-state voltage is used via a rectifier directly to supply the control circuit.

This variant offers the advantage that there is a broad range for dimensioning,
20 because the number of turns of the two auxiliary windings can be selected to be different.

Another expedient variant is characterized in that the forward voltage as well as the off-state voltage are taken from a common auxiliary winding, wherein uncoupling/rectifier diodes rectify the forward voltage and send it to the series
25 regulator, and additional uncoupling/rectifier diodes rectify the off-state voltage and send it to the supply voltage terminal of the control circuit.

This embodiment has the advantage that only a single auxiliary winding, which is present according to the state of the art anyway, is needed, and the present invention can be embodied by means of two additional diodes.

30 Moreover, it is expedient if the output of the series regulator is connected to the storage capacitor via an uncoupling diode. As a result, it is also possible to use

series regulators that do not have an uncoupling diode or equivalent means integrated in them.

The present invention will be explained in greater detail below on the basis of exemplary embodiments, which are illustrated in the drawings. In the drawings,

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■ Figure 1 shows the circuit diagram of a switching converter according to the state of the art,

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■ Figure 2 shows a first embodiment of a switching converter according to the present invention with an additional auxiliary winding, and

■ Figure 3 shows another embodiment of the present invention with a single auxiliary winding.

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The embodiment according to the present invention, as is shown in Figure 2, differs from the circuit according to the state of the art, which is shown in Figure 1, in that an additional auxiliary winding W2, whose off-state voltage is used, is provided at the transformer, which is indicated by a point offset in relation to the windings WP and W1. The off-state voltage is rectified by means of a diode D4 and lies on the storage capacitor Cs.

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The present invention makes use of the fact that an off-state (auxiliary) voltage is automatically also regulated in a combinational switching circuit that operates according to the principle of the flyback converter, because the transformer windings are coupled with one another. The winding W2 is dimensioned now such that the desired supply voltage U_h of the control circuit AST is greater during operation at normal rating than the output voltage U_{h1} of the series regulator LAE, e.g., by about 1 V to 2 V. The voltage outputs U_h and U_{h1} are connected with one another via the uncoupling diode D3, and the control circuit AST is supplied from the winding W2 as long as the voltage U_h is greater than the voltage U_{h1} . This means that no current is

flowing through the series regulator LAE and therefore no power loss occurs in it, either.

If the output voltage U_A decreases in special operating states, e.g., in case of overload or short-circuit, the off-state voltage also decreases correspondingly on the secondary winding WS, and the rectified voltage becomes smaller than U_{h1} . The voltage U_{h1} replaces the voltage U_h in this case and the series regulator LAE becomes active. Therefore, power loss develops on the series regulator LAE in rare cases of operation only, de facto in case of short-circuit at the output. The function is otherwise the same, for example, as far as the start-up of the circuit by means of the resistor R_s and the storage capacitor C_s is concerned, as according to the state of the art.

The circuit according to the present invention, as is shown in Figure 3, shows that a single auxiliary winding W1 may possibly also be sufficient. It must only be ensured that both the forward voltage and the off-state voltage, which is proportional to the output voltage U_A , can be taken from the auxiliary winding W1 in a suitable and uncoupled manner. Based on the circuit according to the state of the art, as it is shown in Figure 1, this can be achieved by introducing an uncoupling diode D2', a rectifier diode D4 and another uncoupling diode D4'. As in the embodiment according to Figure 2, the off-state voltage on the auxiliary winding W1, which is rectified by means of the diodes D4 and D4' and lies on the storage capacitor C_s , is used in the normal case of operation. This rectified off-state voltage drops and the forward voltage on the winding W1, which is rectified by means of the diodes D2 and D2', is used via the series regulator LAE only when the regulated output voltage U_A actually drops, e.g., in case of a short-circuit. The diodes D2' and D4' are also necessary for the mutual uncoupling of the two voltages.

It should be noted that the embodiment of the present invention according to the circuit shown in Figure 3 has the advantage that it needs only a single auxiliary winding W1, but this embodiment is more critical concerning its dimensioning than the circuit according to Figure 2 because it is not possible to determine the off-state voltage and the forward voltage independently from one another, by selecting the turns ratio of W1 and W2.